There is no offset in the preferred embodiment of the invention because it is assumed that offsets cancel each other out, and that the system's 16 processes are zero-mean Gaussian signals. Sigma represents variance, is defined in the implementation phase of the invention by a human developer. It is known in the art how to assign a useful value for sigma by looking at data.

[0081] Next, mode probabilities are updated from the likelihood generated above and the pre-defined markovian mode probabilities discussed above.

$$P^{C} = P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C}$$

$$P^{H} = P^{H\text{-}H} + P^{S\text{-}H} + P^{C\text{-}H}$$

$$P^{S} = P^{S\text{-}S} + P^{H\text{-}S} + P^{C\text{-}S}$$

The equations for the updated mode probabilities are as follows, where L represents the likelihood of a particular mode as calculated above:

Probability of mode Stationary =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} + P^{C\text{-}S}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} + P^{C\text{-}H}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} + P^{C\text{-}S})$$

Probability of mode Human =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} + P^{C\text{-}S}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} + P^{C\text{-}H}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} + P^{C\text{-}H})$$

Probability of mode Crash =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} + P^{C\text{-}S}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H}\ P^{C\text{-}H}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})$$

REMARKS

This preliminary amendment does not add new matter to the application. The first set of clarifying amendments relate to the location of the centroid, which was accidentally misidentified in Figure 4 and correctly disclosed in Figure 5. Corresponding corrections were made to claim 20 and to paragraphs 8, 30, and 35.

The corrections to paragraphs 47 and 81 concern the already disclosed principle that a crash state can transition to a human or stationary state. The underlying mathematics is derived elsewhere in the specification, as unmodified. The correction to paragraph 80 relates to a typographical error relating to how the "offsets cancel each other out."

Applicant respectfully requests entry of the clarifying but non-substantive amendments, and examination on the merits.

Respectfully submitted,

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MARKED UP VERSIONS OF ALL AMENDED CLAIMS

20. An image processing system comprising:

a sensor for capturing an image of a seat area;

a segmentation subsystem for extracting a segmented image of an occupant from an ambient image of a seat area;

an ellipse fitting subsystem which fits an upper ellipse to the upper torso of an occupant, a lower ellipse to the bottom portion of an occupant, and a centroid ~~at a point of intersection between~~ in said upper ellipse ~~and said lower ellipse~~;

a tracking and predicting system, further comprising a shape tracker and predictor and a motion tracker and predictor; and

an at-risk-zone ~~("ARZ")~~ intrusion indicator, wherein said at-risk-zone~~ARZ~~ intrusion indicator determines which point on the upper ellipse is closest to the airbag, and wherein said at-risk-zone~~ARZ~~ intrusion indicator informs the airbag controller whether the occupant will be in a position within a predefined danger zone by the time the airbag is deployed;

wherein said shape tracker and predictor tracks and predicts predefined shape characteristics using a Kalman filter equation for each predefined shape state, and wherein said shape tracker and predictor weighs each Kalman filter using the predefined probabilities associated with said shape states, to generate an overall prediction for each said shape characteristic; and

wherein said motion tracker and predictor predicts predefined motion characteristics using a Kalman filer equation for each predefined motion mode and weighs the predefined probabilities associated with said motion modes, to generate an overall prediction for each said motion characteristic.

MARKED UP VERSIONS OF ALL AMENDED PARAGRAPHS

[0008] A camera or some other sensor is used to capture an ambient image, the image of the occupant and the area surrounding the occupant. A segmented image, the image of the occupant with the surrounding area removed from the image, is obtained through a process called segmentation. The segmented image is then subjected to a~~n~~ shape fitting process that fits an upper shape to the upper torso of the occupant. A lower shape is fitted from the occupant's hips down to the occupant's feet. The two shapes can overlap at one point, the centroid of the occupant, in the area of the occupant's hips. In the preferred embodiment, an ellipse is the shape used and the relevant centroid is the centroid of the upper ellipse.

[0030] The segmented image 42 of the occupant is then subject to an ellipse fitting routine 44. An upper ellipse is fitted around the upper torso of the occupant 18. The upper torso includes everything from the occupant's 18 head down to the occupant's hips. A lower ellipse is fitted from the occupant's 18 toes up to the occupant's 18 hips. Both ellipses overlap at one point which can be~~is~~ referred to as the centroid, but the centroid 54 is preferably identified as the center of the upper ellipse 58. The output of the ellipse fitting routine 44 will be discussed in greater detail below along with the discussion relating to Figs. 4, 5, and 6. The process and practice of generating an upper ellipse, a lower ellipse, and a centroid to represent different parts of the occupant 18 is well known in the art. In the preferred embodiment of the invention, the ellipse fitting routine 44 is applied by the computer system 30, but in other embodiments, the ellipse fitting routine 44 could be performed by a separate computer from the computer system at 30.

[0035] Fig. 4 illustrates the ellipse fitting routine 44 implemented by the computer system 30. The upper ellipse 58 extends from the hips up to the head of the occupant 18. The lower ellipse 56. extends down from the hips to include the feet of the occupant 18. If the entire area from an occupant's 18 hips down to the occupant's 18 feet is not visible, a lower ellipse is generated to represent what is visible. Both ellipses overlap at a point that can be known as the centroid 54, although the centroid 54 is preferably the center of the upper elipse 58. In non-preferred embodiments,

shapes other than ellipses are used to represent the upper and lower parts of an occupant 18. The ellipse fitting routine is well known in the art. The image processing system ~~does~~ need not utilize the lower ellipse 56, and it is preferable ~~only used~~ to generate the centroid 54 with respect to the upper ellipse 58.

[0045] Similarly, the probability of human to human is P^{H-H} at 116, human to stationary is P^{H-S} at 112, and human to crash is P^{H-C} at 120, and stationary to crash P^{H-C} is 90. The total probabilities resulting from an initial state of stationary 102 must add up to 1.

$$P^{H-H} + P^{H-C} + P^{H-S\cancel{C}} = 1.0$$

[0047] As a practical matter, it is highly unlikely but not impossible for an occupant 18 to ever leave the state of crash at 122 once that state has been entered. Under most scenarios, a crash at 122 ends the trip for the occupant 18. Thus, in the preferred embodiment, P^{C-H} is set to a number very close to zero and P^{C-S} is also set to number very close to zero. The three equations for motion mode probabilities in the preferred embodiment are as follows:

$$P^{C-C} + P^{C-H} + P^{C-S} = 1.0$$

$$P^{H-H} + P^{H-C} + P^{H-S} = 1.0$$

$$P^{S-C} + P^{S-H} + P^{S-S} = 1.0$$

[0080] Next, the actual likelihood for each motion vector is calculated.

$$\text{Likelihood}\begin{pmatrix} C \\ H \\ S \end{pmatrix} = e^{-(\text{residue} - \text{offset})^2 / 2\sigma^2}$$

There is no offset in the preferred embodiment of the invention because it is assumed that offsets cancel each other out, and that the system's 16 processes are zero-mean Gaussian signals. Sigma represents variance, is defined in the implementation phase of the invention by a human developer. It is known in the art how to assign a useful value for sigma by looking at data.

[0081] Next, mode probabilities are updated from the likelihood generated above and the pre-defined markovian mode probabilities discussed above.~~:~~

$$P^{C} = P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C}$$

$$P^{H} = P^{H\text{-}H} + P^{S\text{-}H} \underline{+ P^{C\text{-}H}}$$

$$P^{S} = P^{S\text{-}S} + P^{H\text{-}S} \underline{+ P^{C\text{-}S}}$$

The equations for the updated mode probabilities are as follows, where L represents the likelihood of a particular mode as calculated above:

Probability of mode Stationary =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} \underline{+P^{C\text{-}S}}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} \underline{+P^{C\text{-}H}}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} \underline{+ P^{C\text{-}S}})$$

Probability of mode Human =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} \underline{+P^{C\text{-}S}}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} \underline{+P^{C\text{-}H}}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} \underline{+ P^{C\text{-}H}})$$

Probability of mode <u>Crash</u>~~Human~~ =

$$1/[L^{S} * (P^{S\text{-}S} + P^{H\text{-}S} \underline{+ P^{C\text{-}S}}) + L^{H} * (P^{H\text{-}H} + P^{S\text{-}H} \underline{P^{C\text{-}H}}) + L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})] * L^{C} * (P^{C\text{-}C} + P^{S\text{-}C} + P^{H\text{-}C})$$